Terms of Reference for Incorporating Adaptive Management into the Watershed Restoration Program via the Effectiveness Evaluation Process

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1. About this Document

1.1 Purpose of the TOR

The Effectiveness Evaluation (EE) process is the catalyst for incorporating adaptive management (AM) into the Watershed Restoration Program (WRP). This Terms of Reference (TOR) will provide guidance on how to design EE procedures, products and tools to meet that objective. While the TOR will be primarily directed at people who are developing EE guidelines and at EE practitioners, it will also require modifications to the information that flows among all four WRP elements (EE, Plans, Prescriptions, Works).

This document assumes the reader is familiar with adaptive management. A brief summary of the AM approach is presented in Appendix 1.

1.2 Structure of the TOR

Adaptive management is a tool for learning and reducing uncertainty, and thereby making better decisions and improving environmental management (Nyberg 1999; Taylor et al. 1997)[1]. The TOR are therefore organized into four parts:

1. Decisions made within the WRP,
2. Uncertainties that prevent these decisions from being made with confidence,
3. An action plan for reducing this uncertainty and incorporating learning into the WRP, and
4. Challenges to implementing the action plan.

The action plan will primarily focus on EE, but will also involve information input from, and information dissemination to, the other WRP elements.

As decisions within the WRP are made at different scales, and improving decisions is the driver behind AM, the listing of decisions and uncertainties is organized by scale:

- Provincial,
- Regional,
- Watershed, and
- Component.

In some places examples have been provided, and appear in italics. Their purpose is to illustrate the kind of information that is being requested by the TOR.

Please note that, by its very nature, this is an iterative process – as more is learned through applying the AM approach, the uncertainties will change. (In other words, current uncertainties will be resolved, but new ones may emerge.) Therefore while the process described in the EE plans and guidelines that result from this TOR may not change much over time, the uncertainties they aim to address surely will. Therefore, review of the decisions and uncertainties should be a regular part of the "assessment" step within the AM process as applied to the WRP.

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[1] For more information about adaptive management in British Columbia, visit the MOF AM website: http://www.for.gov.bc.ca/hfp/amhome/amhome.htm

Also please note that the current British Columbia Government restructuring due to the creation of the Ministry of Sustainable Resource Management and the Ministry of Water, Land and Air Protection may require minor modifications to this document.

2. Overall Framework for Incorporating AM into WRP

Adaptive management follows a simple set of steps, as shown in Figure 1. However, AM is not just adding a feedback loop – it is a rigorous process that requires specific actions at each step. For example:

- In the Assessment step it is important to clearly state the management objectives and explore alternative hypotheses to determine the key uncertainties (i.e. things that prevent managers from deciding with confidence which treatment/prescription to apply in order to meet the management objectives).
- In the Design step it is important to clearly document assumptions, and to document expected or predicted outcomes from what is prescribed. If operational experiments are being designed, it is important to include sufficient controls and contrasts to be able to draw conclusions from the results. Think ahead – what adjustments will be made (and where) if these predictions are correct (or incorrect)?
- In the Implementation step, it is important than any deviations from the design be clearly documented – otherwise the opportunity to learn will be compromised.
- In the Monitoring step it is important to sample indicators that relate to the original objectives, in order to be able to determine whether the objectives are being met. (The purpose of using the AM approach is to reduce uncertainty regarding how best to meet these objectives.) It is also important to try to conduct pre-treatment sampling for a baseline, and to follow an organized and consistent protocol to facilitate comparisons with other monitoring programs elsewhere.
- In the Evaluation step, it is important to consider the monitoring results together with the objectives, assumptions, predictions, design, and any documented deviations from the design.
- In the Adjustment step it is important not only to use what has been learned to adjust the program (e.g. revise hypotheses, make better predictions, prescribe more effective treatments) but also to share what has been learned with others.

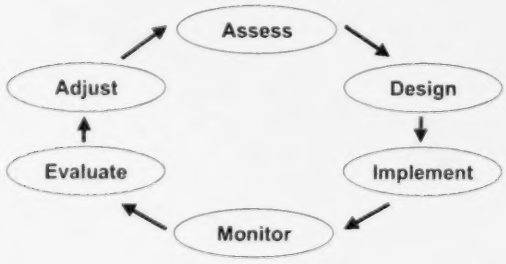

Figure 1. Illustration of the 6 steps that represent the adaptive management approach.

A separate document describes the "Conceptual Model for Incorporating Adaptive Management Principles into the WRP" (ESSA 2001a). Figure 2 shows how information would flow within the WRP if the AM approach were adopted at a **programmatic** level.

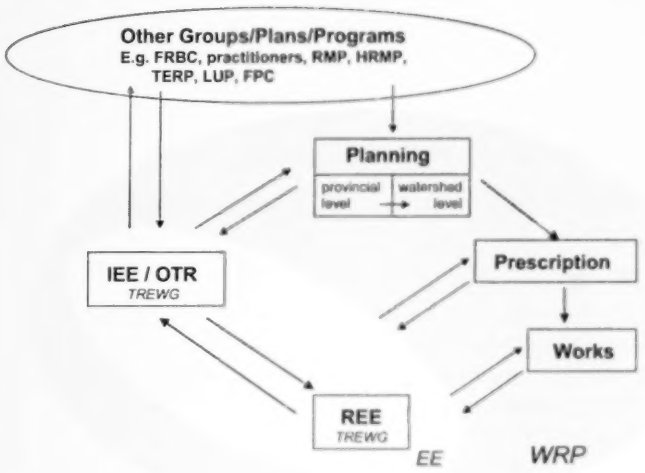

Figure 2. Conceptual model of information flow under an AM approach to the WRP. FRBC = Forest Renewal British Columbia, RMP = Resource Management Plan, HRMP = Headquarters Resource Management Plan, TERP = Terrestrial Ecosystem Restoration Program, LUP = Landscape Unit Planning, FPC = Forest Practices Code.

AM can also be adopted at a **project** level, by undertaking intensive effectiveness evaluations (IEE) and/or operational techniques refinement (OTR) as 'passive' or 'active' AM experiments. This is illustrated in Figure 3. For further explanation, please refer to the Conceptual Model document. This TOR provides instruction on how to incorporate AM principles at both the programmatic and at the IEE/OTR project level.

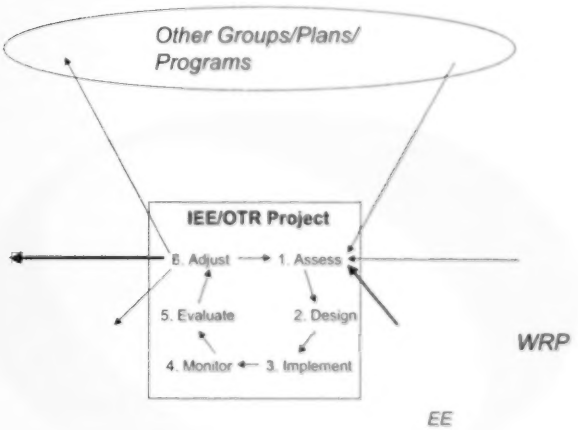

Figure 3. Conceptual model of an AM approach to IEE/OTR projects.

3. Terms of Reference

3.1 Decisions

3.1.1. Identify WRP decisions that are made at the provincial level.

Examples might be:

- *Provincial level goals*
- *Allocation of $ across major regions of province*
- *Fraction of $ spent on effectiveness evaluations (% of $ spent on implementation versus testing hypotheses / evaluation / learning)*
- *Regions/watersheds/components to be the focus of IEE effort across the province*
- *REE/IEE data collection protocols (indicators to measure, and how)*
- *Restoration actions to undergo OTR, and where across the province*

3.1.2. Identify WRP decisions that are made at the regional level.

Examples might be:

- *Regional level objectives*
- *Watersheds worth restoring, and watersheds which are not (I.e., which watersheds should be assessed for restoration potential)*
- *Watersheds of highest priority for restoration*
- *Regional differences in prescribed restoration activities*

3.1.3. Identify WRP decisions that are made at the watershed level.

Examples might be:

- *Watershed level objectives*
- *Component(s) to focus on in each watershed*
- *Role of watershed in regional and provincial WRP design*

3.1.4. Identify WRP decisions that are made at the component level.

Examples might be:

- *Component and site level objectives*
- *Site-level restoration activities, and sites (i.e. prescriptions)*
- *Sites to be targeted for IEE and OTR*

3.2 Uncertainties

3.2.1. Identify the key uncertainties at the provincial level. (I.e. what information gaps prevent us from making provincial level decisions with confidence?)

Examples[2] *might be:*

- *Are we meeting WRP goals? Is WRP working?*
- *What is the success of meeting watershed level and component level objectives across the province?*
- *What is the timeframe for WRP goals? (I.e. by when do we want to achieve these goals?)*
- *Which Ministry is responsible for riparian management? Does this fall under the WRP, EEV, or the Sustainable Harvest program?*
- *Where will IEE give us the 'biggest bang for the buck' in terms of informing us about what's working and what isn't?*
- *How do current Native land claim negotiations affect the WRP, and how will future land claim settlements affect the WRP?*

3.2.1.1 Identify subsets of these provincial level uncertainties that can be addressed through Effectiveness Evaluation (either REE, IEE or OTR).[3]

E.g.:

- *Percent success of all watersheds we've tried to restore*
- *Whether we are meeting WRP goals; whether the WRP is working*
- *Where IEE will give us the 'biggest bang for the buck' in terms of informing us about what's working and what isn't*

3.2.2. Identify the key uncertainties at the regional level.

Examples might be:

- *What constitutes the "point of no return" with respect to restoring natural sediment processes? (triage)*
- *Which watersheds will probably function no better after WRP activities than before (hence not worth restoring)?*
- *Does bioengineering within any of the components (hillslope, riparian, instream) work in the interior of British Columbia?*
- *Do vegetation management activities speed up the recruitment of large woody debris in the interior of British Columbia?*

3.2.2.1 Identify subsets of these regional level uncertainties that can be addressed through Effectiveness Evaluation (either REE, IEE or OTR).

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[2] Some of the example uncertainties are from the results of the February 20-21, 2001 WRP AM workshop (Murray et al. 2001).

[3] Not all uncertainty can be addressed through an AM approach, and not all can be addressed through EE. While the TOR calls for explicitly identifying which uncertainties can be addressed through EE, it also implicitly identifies those uncertainties that cannot – indicating a need for other avenues to be explored for reducing these uncertainties. REE = Routine Effectiveness Evaluation, IEE = Intensive Effectiveness Evaluation, OTR = Operational Techniques Refinement.

3.2.3. Identify the key uncertainties at the watershed level.

Examples might be:

- *When should we control sediment and when not?*
- *Should standards of sediment delivery vary with watershed objectives?*
- *What is the "natural" rate of sediment delivery to aim for?*
- *Which restoration activities are "effective" and which not? (E.g. does re-vegetation successfully stabilize stream banks?)*
- *What is the best allocation of sediment control funds across different components (e.g. hillslope, channel, roads, landslides, gullies) within a given watershed? This may differ among watersheds...*
- *Have fundamental objectives been met through implementation of these plans?*
- *What is the optimum timing and what are the optimum conditions for WRP vegetation management activities within a watershed?*
- *Do hillslope and riparian vegetation management activities decrease sediment delivery to streams? If so, is this helping fish?*

3.2.3.1 Identify subsets of these watershed level uncertainties that can be addressed through Effectiveness Evaluation (either REE, IEE or OTR).

3.2.4. Identify the key uncertainties at the component level.

Examples might be:

- *What objectives should we be managing for in the riparian zone? Should silviculture, biodiversity, or fish resources take precedence?*
- *Is shoot growth a good indicator of root growth? Root growth (and whether the growth is deep and/or lateral) is a good indicator of the site-level success of re-vegetation activities. Pulling up the vegetation will tell you this, but is rather destructive.*
- *Is road deactivation an effective means of preventing excess sediment from entering streams?*
- *What are the future maintenance demands of vegetation management activities within the WRP?*
- *What is the optimum timing and conditions to undertake re-vegetation for bank stability?*
- *When planting streamside vegetation to create shade to keep water temperatures down, which should be given priority: the main stem or first order streams? Or does it matter?*
- *Under what conditions will the activity of planting vegetation on gravel bars for stability have a net benefit for fish?*
- *What is the life span of instream structures? For example, how long will large woody debris stay in place, serving its intended purpose (e.g., protection from bank erosion, creation of fish habitat)?*

3.2.4.1 Identify subsets of these component level uncertainties that can be addressed through Effectiveness Evaluation (either REE, IEE or OTR).

3.3 Action Plan

Develop plans for how data collected through REE, IEE and OTR can be synthesized an analysed to provide feedback to adjust/improve WRP decisions and report on WRP success.

3.3.1. Identify the information that would be needed to resolve those uncertainties that could be addressed through the EE process (i.e. the uncertainties listed in sections 3.2.1.1, 3.2.2.1, 3.2.3.1, 3.2.4.1).

3.3.2. Of the information needs listed in section 3.3.1, identify which can be fulfilled via REE, and which will need IEE or OTR.

Example format:

	REE	*IEE*	*OTR*
info need 1	✓		
info need 2		✓	
info need 3	✓		
info need n			✓

3.3.3. Write a plan to periodically re-do the steps thus far in the TOR (section 3.1, 3.2, 3.3.1 and 3.3.2), so there is a regular assessment of what information the EE process should be providing back to the rest of the WRP. Regular re-assessment is necessary because information needs will change over time as learning occurs.

3.3.4. Write a plan for how REE will be carried out. This includes how the information (as per the REE column in section 3.3.2) will be collected, recorded and evaluated, and how WRP will be adjusted based on what is learned. Be sure to cover all of the information flows illustrated in Figure 2 (except outputs from IEE/OTR, which will be covered in sections 3.3.5 and 3.3.6). This should include instructions on:

- Using information from the Planning/Overview Assessment stage (objectives, uncertainties), Prescription stage (assumptions, uncertainties, predictions) and the Works stage (deviations from prescription, changes in assumptions) as described in section 5 in combination with the REE results to determine what has been learned.
- How what has learned, and the necessary adjustments to the WRP, will be communicated to others within and outside the WRP. (This is necessary so the assumptions and uncertainties can be revised within the Planning and Prescription stages).

Also, candidly address the limitations of REE. For example, do indicators collected through routine monitoring assess effectiveness, or only compliance? When is the best time to measure effectiveness? (I.e., for how long after the works are completed, and at what intervals? When and for how long after storm events?) Can REE be conducted according to the necessary timing and frequency to monitor effectiveness?

3.3.5. Write a plan for how REE results and other information (from within and outside WRP) will be used to decide on topics for IEE and OTR. This plan is represented by the Assess step in Figure 3. Decisions on topics for IEE and OTR will come from uncertainties and information needs listed above in section 3.3.2 (i.e. key information

gaps we already know about), and from information that is learned through REE (i.e. information gaps that come to light from REE results). The plan should include instructions for creating a WRP knowledge base, and for updating it as learning progresses.

3.3.6. Write guidelines for how to carry out IEE projects. (If IEE projects are contracted out, then a portion of the guidelines should direct the preparation of an RFP.) This includes how the information (as per the IEE column in section 3.3.2) will be collected and evaluated, and how WRP will be adjusted based on what is learned. Be sure to cover all of the steps, inputs and outputs illustrated in Figure 3 (except the Assess step, which is covered in section 3.3.5). The guidelines should include instructions on:

- Clearly stating the objectives of the IEE project, and documenting assumptions.
- Documenting predicted outcomes from the experiment, before any treatments are undertaken.
- Careful consideration of experimental design criteria, including the scale at which the experiment should be undertaken to address the uncertainty in question, sufficient contrasts (which also relates to scale, in terms of stratification within or among watersheds/regions), controls, and a monitoring period and duration sufficient to detect a response. Consultation with a biometrician should be recommended, to ensure the experimental design is adequate to answer the question(s) the experiment is trying to address.
- Developing consistent monitoring protocols to be applied across IEE projects to increase the scope within which the results can be compared and interpreted.
- Selecting monitoring indicators that relate to the objectives, in order to be able to determine whether the objectives are being met.
- How the IEE results will be evaluated by considering the monitoring results together with the objectives, assumptions, predictions, design, and any documented deviations from the design.
- How what has learned will be communicated to others within and outside the WRP.
- How the necessary adjustments to the WRP, based on what is learned, will be communicated to others.

3.3.7. Write guidelines for how to carry out OTR projects. (If OTR projects are contracted out, then a portion of the guidelines should direct the preparation of an RFP.)This includes how the information (as per the OTR column in section 3.3.2) will be collected and evaluated, and how WRP will be adjusted based on what is learned. Be sure to cover all of the steps, inputs and outputs illustrated in Figure 3 (except the Assess step, which is covered in section 3.3.5). The guidelines should include instructions on the same issues listed for IEE under section 3.3.6.

3.4 Challenges

3.4.1. List the challenges (political/legal, institutional, economic, public/social, and technical) in implementing the plans and guidelines described in sections 3.3.3 - 3.3.7.

Examples might be:

- *Different interpretation of priorities among regions, undermining the ability to aggregate EE results to the provincial scale*
- *Short-term focus of funding agency (FRBC); hard to fund long-term studies (which are necessary for IEE)*
- *Lack of consultant expertise to undertake IEE/OTR*
- *Cumbersome organizational structure (multi-agency, overlapping regions, inefficient division of responsibilities within a given watershed, government reorganization)*
- *Shortage of staff*
- *Difficulties in developing and applying consistent monitoring protocols across watersheds*

3.4.2. Outline an action plan for addressing (or continuing in spite of) each of these challenges.

4. Recommended Participants

Table 1 outlines the types of people who should be involved in undertaking the tasks described in the TOR.

Table 1. Suggestions on who should undertake the tasks described in the TOR.

Section of the TOR	Who should be involved in responding to this section
3.1Decisions	- People involved in making WRP decisions at the given scale (provincial, regional, watershed, component), both in MSRM/MWLAP[4] and MOF
3.2 Uncertainties	- People involved in making WRP decisions at the given scale, both in MSRM/MWLAP and MOF - People knowledgeable in AM, with a neutral perspective who can "critique" these decisions (play devil's advocate and ask probing questions) - People with domain expertise who can distinguish between what's known and what is not known
3.3 Action Plan	- People knowledgeable with WRP procedures, in both MSRM/MWLAP and MOF - People knowledgeable in AM (AM expert)
3.4 Challenges	- People knowledgeable with WRP procedures, in both MSRM/MWLAP and MOF - Senior WRP managers, FRBC - People knowledgeable in AM (AM expert)

[4] Whichever Ministry assumes WRP responsibilities from the former Ministry of Environment, Lands and Parks.

5. Implementing AM Beyond EE

As described earlier, EE is the primary mechanism for incorporating AM into the WRP, and has therefore been the focus of the TOR. However, there are other places within the WRP where AM principles should be applied for the AM approach to be most effective. These are described below (and should be done in addition to the regular procedures for each stage, according to the Standards Agreements).

5.1 Planning/Overview Assessment Stage

- Document management objectives.
- Document uncertainties (this will help in the EE assessment described in section 3.3.3).
- Describe what changes might occur to the WRP if these uncertainties are resolved through EE.
- Explore and document alternative hypotheses (to assist in selecting a prescription).

5.2 Prescription Stage

- Document rationale for the selected prescription.
- Document any associated assumptions and uncertainties.
- Document predicted outcomes from the prescriptions (so that expected outcomes can be compared against actual outcomes in the evaluation process, which is necessary for learning to occur).
- Provide information on objectives, assumptions and uncertainties to licensees who will perform the works, so they understand the importance of sticking to the prescription, and of documenting any deviations from it.

5.3 Major Works Stage

- Document any deviations from the prescription, and the rationale for the deviation.
- Document any site-specific characteristics that differ from the assumptions that emerged from the prescription stage.

6. References

ESSA Technologies Ltd. 2001. Conceptual Model for Incorporating Adaptive Management Principles into the WRP. Prepared for BC Ministry of Forests, Resource Tenures and Engineering Branch, Victoria, BC, 3 pp.

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Taylor, B., L. Kremsater and R. Ellis. 1997. Adaptive management of forests in British Columbia. B.C. Min. For., Victoria.

7. Abbreviations

AM	Adaptive Management
EE	Effectiveness Evaluation
FPC	Forest Practices Code
FRBC	Forest Renewal British Columbia
HRMP	Headquarters Resource Management Plan
IEE	Intensive Effectiveness Evaluation
LUP	Landscape Unit Planning
MOF	British Columbia Ministry of Forests
MSRM	British Columbia Ministry of Sustainable Resource Management
MWLAP	British Columbia Ministry of Water, Land and Air Protection
OTR	Operational Techniques Refinement
REE	Routine Effectiveness Evaluation
RFP	Request for Proposals
RMP	Resource Management Plan
TERP	Terrestrial Ecosystem Restoration Program
TOR	Terms of Reference
TREWG	Technical Review and Evaluation Working Group
WRP	Watershed Restoration Program

Appendix 1

A Brief Summary of Adaptive Management

Adaptive management (AM) is a systematic, rigorous approach for learning (Nyberg 1999; Taylor et al. 1997). The goal of AM is to reduce "key" management uncertainties: things that hinder the ability of a manager to confidently decide among alternative actions. The approach is comprised of six conceptual steps.

Step 1: Assess

Clearly define and bound the problem. This includes identifying:

- the resource management objectives to be achieved;
- the actions that could be taken to achieve the objectives;
- the indicators we should measure to determine if the actions are indeed achieving the desired objectives;
- the spatial and temporal boundaries/scale of the actions/indicators;
- the key uncertainties (key things we don't know about how the actions will affect the indicators);
- hypotheses regarding the uncertainties (predictions about how we expect the indicators to be affected by various actions); and
- what we will do if we learn that our hypotheses are correct (or incorrect).

Step 2: Design

Design an Implementation Plan that details what specific actions will be taken (when, where, how) to test the hypotheses and target the key uncertainties identified in Step 1. Testing hypotheses involves creating contrasts in time and/or space. This Implementation Plan should contain sufficient detail for a contractor to properly carry out all prescribed activities.

This step also includes the preparation of a detailed Monitoring Plan, specifying the sampling design, scale, variables and methods.

Biometricians should be involved in this step, to ensure that the sampling design is sufficient to statistically detect effects that are environmentally and operationally important, given the natural variation in indicators over time and space. (It should also be noted that while AM is usually driven by management objectives and uncertainties, research scientists are key partners /collaborators in AM experiments, and should be involved in all six steps.)

Step 3: Implement

Undertake the activities/management prescriptions according to the Implementation Plan. All aspects of the Plan must be adhered to, including the prescribed locations and timing of management actions.

Step 4: Monitor

There are three aspects to this:

1) Monitoring implementation to ensure that the activities were undertaken as prescribed (also called 'inspection').
2) Monitoring environmental variables (also called 'indicators') to learn whether the activities worked (i.e. achieved original objectives).
3) Monitoring variables to test alternative hypotheses for key uncertainties (e.g. does method A do a better job of preventing

erosion off steep slopes than method B? How do the costs of the two methods compare?).

Step 5: Evaluate — Analyse the monitoring data to learn "what happened", and then compare the results with the hypotheses and objectives documented in Step 1 to learn: a) were our hypotheses correct, and b) did the activities meet the objectives? This step focuses on learning; you learn whether your predicted outcomes were accurate, and gain knowledge about what activities best achieve the desired objectives.

Step 6: Adjust — Alter policy, plans, practices and/or prescriptions as warranted based on what was learned. This is the cornerstone of AM: changing what you do next time as a result of what you learned from past experience. While this sounds obvious and simple, it does not occur that often in traditional management because we do not tend to formally recognize uncertainties and then explicitly design management actions to reduce these uncertainties. Thus, Steps 1 and 2 have a big influence on your ability to make adjustments in Step 6.

The AM approach is also characterized by the following elements:

- learning is the explicit goal;
- uncertainty is also recognized and stated explicitly;
- "need-to-know" questions are distinguished from "nice-to-know" questions;
- all stages of the AM process are clearly documented (not only what has been done, but also why); and
- early in the process you not only predict the outcomes of your treatments, but you also state what you will do under various outcomes (i.e. what will happen in Step 6?).

There are two types of AM: "passive" and "active".

Passive AM — Alternatives are assessed in Step 1, and then in Steps 2 and 3 you design and implement the activity that you think will best meet your objectives. You then monitor and evaluate the results to see if you were right (Steps 4 and 5) and make adjustments accordingly.

Active AM — You explicitly recognize in Step 1 that you don't know which activities are best, and then select several alternative activities to design and implement in Steps 2 and 3. You then monitor and evaluate the results of each approach to see which was more effective in meeting your objectives, and make adjustments to what you do next time based on what you have learned.

Passive AM may be initially less expensive and require fewer people to be involved, because you are only implementing one alternative. However, if you are incorrect in your assumption about what is 'best', then it can take longer to learn what activities are indeed the most effective. The absence of a formal comparison of alternatives may mask weaknesses in the approach assumed to be "best". You may need to go through several iterations of passive AM experiments. Active AM may require a larger initial investment of resources (time, people, funds) but since several alternatives are tested the learning happens faster and you may need fewer iterations to find the best alternative.